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RATES OF PRECIPITATION FROM PSEUDO-ADIABATICALLY ASCENDING AIR

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[Hydrometeorological Section, Weather Bureau, Washington, November 1943]

IN the MONTHLY WEATHER REVIEW for October 1935 J. R. Fulks published a method for the calculation of the rate of precipitation from adiabatically ascending air.[1] A simpler method for computing rates of precipitation can be developed by using a storage equation for a vertical column of saturated air with pseudo adiabatic lapse rate.

In such a column of unit cross section, the rate of moisture inflow at the bottom, minus the rate of moisture outflow at the top, equals the rate of storage or the rate of precipitation.

Let

ρ_w=absolute humidity, g/m³,
ρ=density of air, g/m³,
V_z=vertical velocity, m/s,
I=rate of precipitation, in./hr.

Then, using the subscript 0 to refer to the bottom of the column, 1 to refer to the top,

$$\text{Rate of inflow}=V_{z_0}\rho_{w_0},$$

$$\text{Rate of outflow}=V_{z_1}\rho_{w_1},$$

$$I=(V_{z_1}\rho_{w_0}-V_{z_1}\rho_{w_1})\frac{3600}{10}\times 0.3937$$

$$=\frac{(V_{z_0}\rho_{w_0}-V_{z_1}\rho_{w_1})}{7}\text{ in./hr., approximately}$$

If no convergence or divergence occurs between top and bottom of the column, the mass of air flowing upward per unit time will be constant (neglecting the loss of water by precipitation) and equal to

$$V_{z_0}\rho_0=V_{z1}\rho_1$$

$$\therefore V_{z1}=\frac{\rho_0}{\rho_1}V_{z0}$$

However, if x is the mixing ratio, then

$$\rho_{w_0}=x_0\rho_0$$

and

$$\rho_{w_1}=x_1\rho_1.$$

Substituting,

$$I=\frac{V_{z0}\rho o(x_0-x_1)}{7}\text{ in./hr.}$$

The x values used should be the actual mixing ratios, that is, the values as read off the pseudo-adiabatic chart divided by 10^3. The density can be obtained from the formula $\rho=348.4\ p/T$, where p is in millibars and T is absolute temperature. Unlike Fulks' method, the equation involves no neglect of the variation of density with height; the results of the two methods therefore differ least in the unit 100-meter depth used by Fulks. For greater depths, the difference is larger, Fulks' values being the lower.

[1] J. R. Fulks, Rate of Precipitation from Adiabatically ascending Air, Mo. WEA. REV., 63:291-294, 1935.

Note by Editor.—In a note by H. R. Byers, appended to this paper, an alternative formula is derived which is stated to differ only inappreciably from Fulks' result, but actually it may give values considerably in error, as the following examples show:

T	P	Fulks	Byers
	Mb.	*Mm./hr.*	*Mm./hr.*
0°	500	0.44	0.61
10	900	.75	1.09